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J. D. WILSON

O. K. HEDDEN

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
WOOSTER, OHIO

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J. D. WILSON[1] and O. K. HEDDEN[2]

INTRODUCTION

The cherry "replant-problem," a term used to denote the retardation of growth when young cherry trees are replanted in an area previously occupied by an old cherry orchard, has been observed in many instances (2, 7, 12, 14, 18). A similar condition has been observed for other fruit trees such as peach and apple (3, 5, 8, 10, 11).

This stunting of young trees as they are becoming established after being transplanted is brought about primarily by the attack of various plant parasitic nematodes on the newly developing feeder roots. These attacks result in a pruning of the root system.

Several genera of these nematodes usually are present in old or established orchard sites (6, 8, 17). However, the injury has been attributed in most instances to *Pratylenchus* spp. and more specifically to *P. penetrans* (3, 5, 10, 11, 14, 18). It is also possible that parasitic nematodes may be present in or on the roots of the young trees as they are received from the nursery (1, 2, 6, 8, 10, 18) and that these persist and cause damage after the trees are transplanted. Other nematode genera (in addition to *Pratylenchus* spp.) often found to be present in appreciable numbers in orchard and tree nursery soils are *Meloidogyne, Xiphinema, Aphelenchoides, Paratylenchus,* and others (1, 3, 6, 8, 12, 14, 17, 18).

As the development of the root system is retarded, twig growth is also diminished and profitable bearing of trees is delayed. Excessive nematode damage has been found in some instances to increase winter injury by delaying maturity in the fall beyond the usual date for more nearly normal plants (11, 12, 15, 16).

The number of parasitic nematodes found in or on the roots or in the root zone of a suitable host plant tends to decrease, sometimes rapidly, following a decline in the growth rate or the death of the host plant. Thus, the length of time between the removal of an old cherry orchard and the planting of a new one in the same place is an important factor in determining the degree of nematode injury which may occur on newly

[1]Professor Emeritus of Plant Pathology, Ohio Agricultural Research and Development Center, Wooster, and The Ohio State University, Columbus.

[2]Research Agricultural Engineer, Agricultural Research Service, U. S. Department of Agriculture, Wooster, Ohio.

planted trees (10). To avoid a lengthy waiting period before replanting, an alternate method is to treat the soil with chemicals to decrease the nematode population. Such an experiment is the subject of this paper. Research experience in various states has shown that nematode damage to young trees in the nursery or in the newly planted orchard can be greatly reduced by soil treatment with such compounds as DD, EDB, and DBCP (1, 2, 3, 7, 9, 14, 18) before planting.[3]

PROCEDURE

Test 1: During the summer of 1957, an experiment was designed in which EDB and Telone were to be applied as soil treatments in an area near Bellevue, Ohio, which was to be replanted to cherries 4 years after a 30-year-old cherry orchard had been removed. Successive crops of tomatoes and pumpkins were grown in the cleared field during the 4-year interval after the old cherry trees were taken out. On October 9, two strips of soil each 20 feet wide and nearly 1000 feet long were treated, one with EDB and the other with Telone (4). A similar strip was gone over with the same tool, without the addition of a chemical, to serve as an untreated check plot. The injector blades were spaced 10 inches apart and the chemicals were introduced into the soil at a depth of 8 inches. At the time of treatment, the sandy soil of the site was at a moisture content suitable for fumigation and at a temperature of 66° F. After treatment, the entire treated area was harrowed lightly and then cultipacked to aid in sealing the soil surface against too rapid loss of the nematocides.

In the spring of 1958, the three 1000-foot strips were planted to Montmorency cherry trees, spaced 25 feet apart. Slight growth differences were noted in 1959 for the trees planted in the three different soil treatments but measurements of twig growth were not made until late in the summer of 1960. The number of plant parasitic nematodes present in soil samples obtained from the root zones of the same trees was determined (14, 17) by means of a modified Baermann funnel technique (13). Additional measurements (twig length, tree height, crown width, and trunk diameter) were made at intervals during the next 6 years. Yield data were obtained in 1965.

Test 2: In 1960 the authors decided to enlarge the experiment by treating additional strips of soil in an area adjacent to the one described above. This portion of the original orchard had not been planted to cherry trees but had been planted to successive crops of pumpkins during

[3]Mention of a proprietary product in this publication does not constitute a guarantee or warranty by the U. S. Deparment of Agriculture or the Ohio Agricultural Research and Development Center and does not imply approval of any product to the exclusion of other products which may also be suitable.

the years 1958-60 inclusive. The treated strips were only 15 feet wide in this instance, with an intervening 10-foot strip of untreated soil. Ten treatments and an untreated check strip were included in this portion of the experiment.

The chemicals were applied in late October with the same equipment and in the same manner as described for the 1957 portion of the experiment. In the spring of 1961, the differently treated strips of soil were planted to Montmorency cherry trees. Growth measurements and a census of nematode populations were made each year from 1961 through 1965. Final growth measurements were made in September 1966.

RESULTS

Test 1: The comparative growth of trees planted in the three differently treated strips of soil in the spring of 1958, following treatment in October of 1957, was determined at yearly intervals beginning in August 1960. The data on twig growth, tree height, and crown spread (width) for the years 1960, 1963, and 1966 are given in Table 1. Data are also given on trunk diameters in 1966 and on fruit yields in 1965 only.

The trees growing in the soil treated with Telone were consistently larger than those in the EDB plot. Those in the untreated check were smallest in all categories of measurement. The comparative sizes of the average trees in 1966 in the differently treated plots are shown in Figure 1. Twig growth declined each year in all plots after 1960 but changed least in the check trees. As a result, the average growth on the check trees in 1966 was similar to that for the trees growing in the plot treated with EDB. However, as a result of the cumulative growth over a period of 9 years, in 1966 the average crown width of the check trees was nearly 2 feet less than in the EDB plot and 4 feet less than in the area treated with Telone. The height differences were in the same order, as were those of trunk diameter. As a result, the differences in crown volume (height x width) accounted for a yield increase over the check trees of about 40 percent for the trees in the EDB plot and more than 150 percent for those in the area treated with Telone.

The number of plant parasitic nematodes present in the soil of the root zone of the trees in the differently treated plots was determined during the month of August in 1960, 1963, and 1965. The average populations for the 3 years are given in the second section of Table 1. Data are given for *Pratylenchus* (lesion), *Paratylenchus* (pin), and *Xiphinema* (dagger), although three or four other genera, including *Meloidogyne* (root-knot), were present in various samples in small numbers.

The population averages given in Table 1 indicate a considerable difference in the number of lesion nematodes present in the differently

TABLE 1.—Effects of Two Nematocides on the Growth of Young Trees Replanted in Soil from which an Old Cherry Orchard Had Been Removed and the Average Nematode Populations During a 6-Year Interval Following Soil Treatment. Growth Data Are Averages for 10 Trees in Each Instance.

Treatments*	Gallons Applied per Acre of Treated Soil	Tree Height in Feet			Crown Width in Feet			Twig Growth in Inches		
		1960	1963	1966	1960	1963	1966	1960	1963	1966
EDB	15	4.76	7.60	10.52	3.66	6.54	12.72	13.4	10.1	9.1
Telone	40	5.04	9.64	12.24	3.78	8.42	14.77	15.8	12.8	11.0
None (Check)	—	4.56	7.00	9.00	2.93	5 50	10.88	9.8	9.5	9.5

		Diameter of Trunk in 1966 (Inches)	Fruit Yield in 1965 (Lb.)	Nematodes† per Pint of Root Zone Soil. Data Are Averages of Years 1960, 1963, and 1965		
				Lesion	Pin	Dagger
EDB	15	4.70	12.0	677	397	88
Telone	40	5.45	22.3	538	343	52
None (Check)	—	3.79	8.7	1330	850	300

*EDB (Dowfume W-85)=ethylene dibromide 83%. Telone=1,3-dichloropropene and related chlorinated C_3 hydrocarbons.
†Lesion nematode=**Pratylenchus penetrans;** Pin=**Paratylenchus** spp.; Dagger=**Xiphinema americanum.**

A.—Telone at 40 gallons per acre B.—EDB at 12 gallons per acre C.—Untreated check

Fig. 1.—Comparative sizes of cherry trees 9 years after planting in differently treated strips of soil on the site of an old cherry orchard. Note numbers denoting height and breath.

TABLE 2.—Relationship Between Tree Growth and Application of Various Nematocides to the Soil from which an Old Cherry Orchard Had Been Removed Several Years Previously and Replanted with Cherry Trees Following Treatment. Effects of Treatments on Nematode Populations During a 5-Year Interval Following Application of Nematocides. Trunk Diameter Measurements Made 18 Inches Above Soil Surface.

Treatments*	Gallons Applied per Acre of Treated Soil	Average Twig Growth in Inches 1962-65	Tree Size in 1966			Average Number of Nematodes† per Pint of Root Zone Soil for 1961-65		
			Height in Feet	Crown Width in Feet	Trunk Diameter in Inches	Lesion	Pin	Dagger
1. EDB	12	13.1	8.0	10.9	3.20	587	6960	0
2. EDB	18	13.9	8.6	11.1	3.65	514	6660	0
3. Telone	30	13.4	8.6	11.8	3.65	758	8778	0
4. Telone	45	15.5	9.4	13.5	4.15	101	5760	78
5. DBCP (Fumazone)	8	14.6	9.0	12.4	3.80	712	2520	25
6. DBCP	12	14.9	9.2	12.0	3.95	282	750	68
7. SMDC (Vapam)	60	15.2	9.2	13.3	4.05	231	4598	172
8. Vorlex (33%) active	100	14.9	9.4	12.8	3.95	141	2946	0
9. Chloropicrin	35	12.9	9.2	12.4	3.75	1961	2090	0
10. Nemex	35	12.4	8.0	11.6	3.45	1789	1860	0
11. None (Check)		12.1	7.8	10.6	3.10	4835	4310	222

*EDB (Dowfume W-85)=ethylene dibromide 83%. Telone=1,3-dichloropropene and related chlorinated C_3 hydrocarbons. DBCP (Fumazone 70-E)=dibromo chloropropene (67.5% emulsifiable). SMDC (Vapam)=sodium N-methyl dithiocarbamate (32.7%). Chloropicrin=trichloro nitromethane. Vorlex=methyl isothiocyanate (20%) and chlorinated C_3 hydrocarbons. Nemex=chloropicrin 50% + chlorinated hydrocarbons 50%.

†Lesion nematode=**Pratylenchus penetrans;** Pin=**Paratylenchus** spp.; Dagger=**Xiphinema americanum.**

treated plots. It is possible that variations of even this magnitude accounted for the growth differences occurring in the trees planted in the three different plots. The population differences were greater in 1960 than in 1965.

Test 2: Twig growth was measured on the trees of this test for 4 successive years starting in 1962. Tree-size measurements, consisting of height, crown width, and trunk diameter determinations, were made in the fall of 1966. These data are presented in Table 2.

Three of the nematocides were applied at two rates on the chance that the higher rate might be more effective in the control of any nematodes which might be present. The growth data, as well as other data on nematode populations in the soil of the differently treated plots (also presented in Table 2), indicate that the higher use rates gave better results with EDB, Telone, and DBCP.

The greatest average twig growth occurred in the plot treated with Telone at 45 gallons per acre and was closely followed by SMDC (Vapam). Vorlex and 12 gallons per acre of DBCP (Fumazone) also promoted good growth. Growth was comparatively poor with Nemex and the lower rate of EDB, with each of these ranking only slightly above the check in all four categories of growth measurement

Lesion nematode populations were highest in the untreated check plot, with the chloropicrin and Nemex-treated soils also exhibiting comparatively high numbers. There were differences of considerable magnitude in both the number of lesion nematodes per unit of soil volume and in tree growth between the plots treated with 30 and 45 gallons of Telone. This may indicate two things—that 30 gallons of this material was insufficient to greatly reduce the population of lesion nematodes and that the presence of this nematode in the root zone of the young cherry tree was the most important factor in regulating growth.

Good growth in the plots treated with SMDC, Vorlex, and DBCP at 12 gallons per acre was also accompanied by comparatively low populations of lesion nematodes. Rather poor growth with 18 gallons of EDB was accompanied by a fairly high population of *Pratylenchus* in this experiment.

Pin nematode population numbers varied rather widely with the different treatments. They were high with EDB, Telone, and SMDC. However, as mentioned earlier, there is little evidence that this species plays an important role in regulating the growth of fruit trees. Dagger nematodes were absent from six of the eleven plots and were comparatively scarce even in the untreated check. It is likely that the low populations present had little effect in depressing tree growth.

SUMMARY

Several nematocides were applied in the fall as preplant treatments in an area from which an old cherry orchard had been removed a few years previously. The treated sites (strips 20 feet wide and the length of the old orchard) were replanted to sour cherry trees (Montmorency) the following spring.

Measurements of length of twig growth, tree height, crown width, and trunk diameter were made in late summer for several years. Soil sampls from the root zone of the differently treated trees were made each August over a period of several years.

In one experiment, EDB and Telone were applied in the fall of 1957. The trees planted in the plot treated with Telone grew much better than in an untreated check plot and considerably better than in soil treated with EDB. Crown width in the Telone plot exceeded that in the check by 4 feet at the end of 8 years and crown width in the EDB plot was intermediate between the two. In the 1 year when the collection of yield data was possible, the trees in the plot treated with Telone yielded two and one-half times those in the untreated check. Trees in the EDB plot again were intermediate in fruit production.

Three nematode genera were present in the sandy soil of the experimental area—*Pratylenchus* (lesion), *Paratylenchus* (pin), and *Xiphinema* (dagger). Only lesion nematodes were judged to be a critical factor in regulating tree growth. These were two and one-half times as numerous in the untreated check site as in the one treated with Telone. Only half as many were found in the EDB plot as in the check.

In another portion of the experiment, 10 treatments (7 different nematocides) were applied to similar strips, but only 15 feet wide, in the same orchard area in the fall of 1960. Three of the seven chemicals (EDB, Telone, and DBCP) were used at two rates.

Data on tree growth and nematode populations were taken at yearly intervals for 5 years. Tree growth, in terms of all four types of measurements, was best at the end of the experiment (fall of 1966) in the plot treated with 45 gallons of Telone per acre. It was nearly as good in plots treated with SMDC, 18 gallons per acre of DBCP, and Vorlex. Growth was comparatively poor with chloropicrin, Nemex, and EDB. Growth in all treated plots was at least as good as in the untreated check.

Lesion nematode populations were comparatively low in plots where growth was good and considerably higher where tree growth was not as good.

The results obtained in the two portions of this experiment indicate that the soil in an area from which an old cherry orchard has been re-

moved should be treated before it is replanted to cherry trees. They show that under conditions as in this experiment, Telone probably is preferred over EDB for the preplant treatment. This may be a further confirmation of the fact that DD frequently gives better control of *Pratylenchus* than EDB does. Telone may be the equal of any other treatment now available for this purpose. Further, the data on the populations of parasitic nematodes present in the differently treated plots tends to substantiate the conclusions of other workers that the presence of the genus *Pratylenchus* in the root zone of cherry trees is a factor that may retard the growth of newly transplanted trees.

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